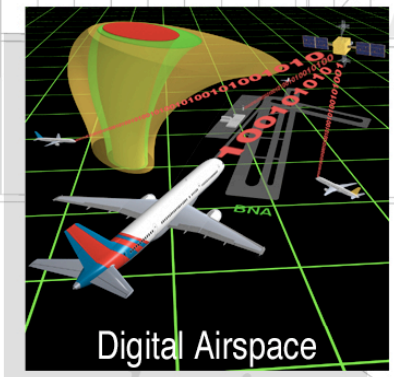
The NASA Aeronautics Blueprint - Toward a Bold New Era of Aviation



Executive Summary

- Aviation is crucial to U.S. economic health, national security, and overall quality of life.
- Our Nation is facing serious challenges in aviation.
- NASA's Aeronautics Blueprint outlines the advanced technologies that can help solve today's problems and create a new level of performance and capability in aviation:
  - Advanced concepts for the airspace system
  - Revolutionary vehicles with significantly greater performance
  - New paradigm for safety and security
  - Assured development of the capable workforce of the future
- **The cost of inaction is gridlock, constrained mobility, unrealized economic growth, and loss of U.S. aviation leadership.**

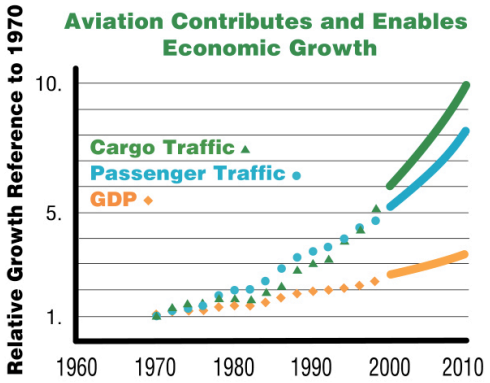
The Imperative

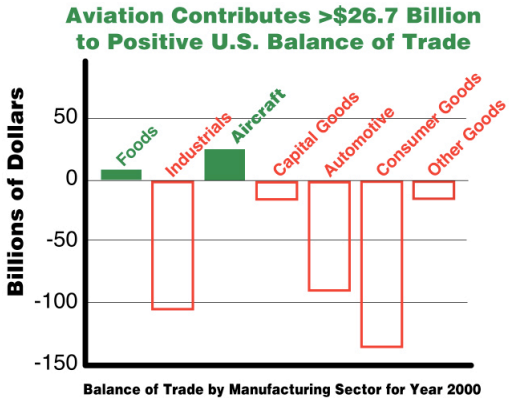
Aviation is Critical to the U.S.

Economic Growth
- Productivity
- Global Competition
- Fullest Commercial Use

National Security
- Air Superiority
- Global Mobility

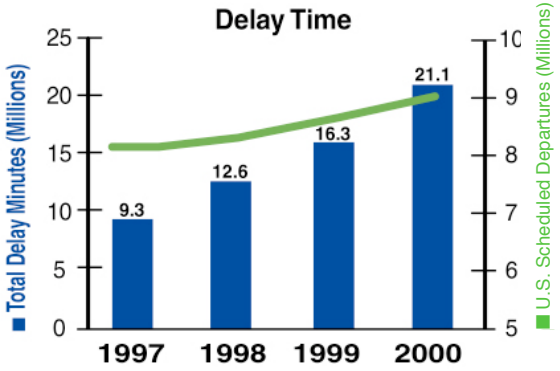
Quality of Life
- Freedom of Movement
- General Welfare



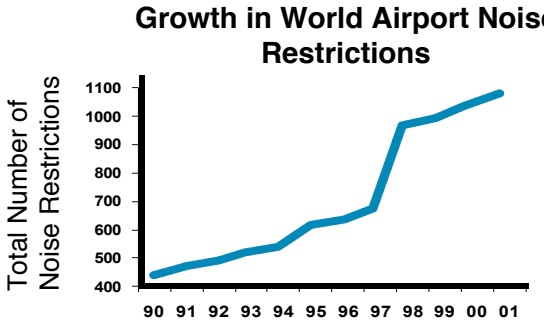


Key Aviation Challenges

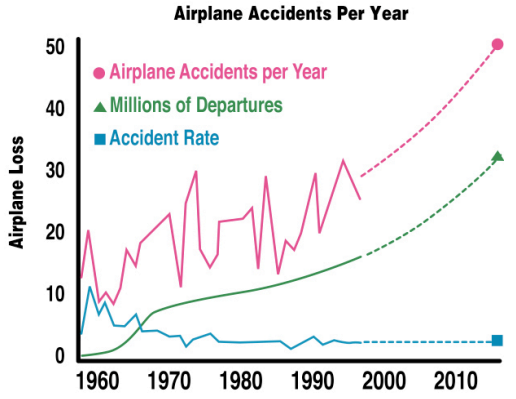
- **Limits to capacity - U.S. aviation system is approaching gridlock.**



- **Noise and emissions are constraints on aviation growth.**



- **Security and safety must be maintained.**

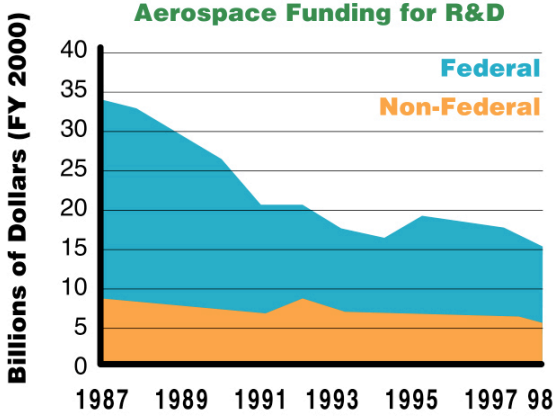


Key Aviation Challenges (Continued)

- The changing national security threat demands technical superiority.

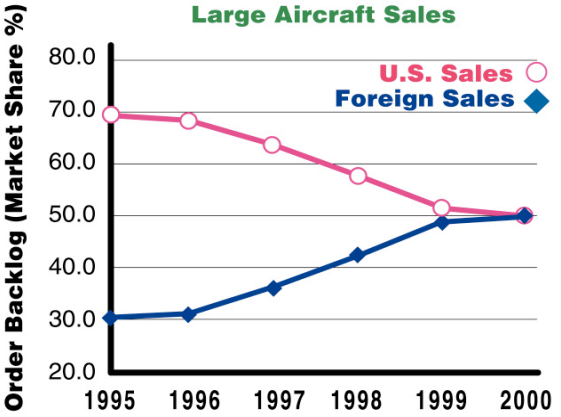
Courtesy of IKONOS

- Aerospace R&D investments and skilled workforce are declining.



- The U.S. is losing global market share and leadership.

European Aeronautics Strategic Plan for Winning Global Leadership



Role of Government in Aeronautics Research

Government Responsible to Provide:

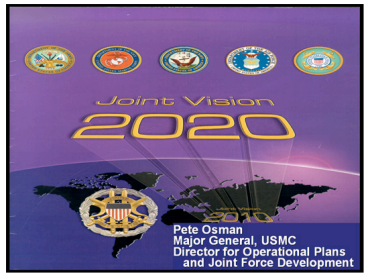
Air Traffic Operations	Enabling Technology in the National Interest	National Security
■ Safe and secure ■ Environmentally compatible ■ Meet growing demand	■ Basic research ■ High-risk technology ■ Unique facilities ■ Educated workforce	■ Air superiority ■ Technical superiority ■ Full-spectrum dominance

- **Technologies flow between civil, military, and commercial applications**
- **Need for Government role in aeronautics technology**

Ongoing NASA/DoD Collaboration

NASA is collaborating in strategic planning and is providing technical solutions to DoD:

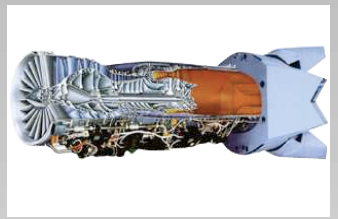
- DoD Joint Vision 2020



- Quadrennial Defense Review Report

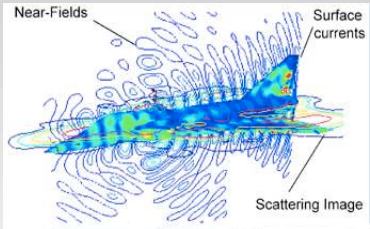
Programs


Aging Aircraft


High-Performance Propulsion


Autonomous Operations

Revolutionary Vehicles



Reduce Design Cycle Time & Development Tools

- Safety of flight
- Affordability
- Reduced noise and emissions
- Lightweight, high-strength adaptable structures
- Adaptive controls
- Situational awareness

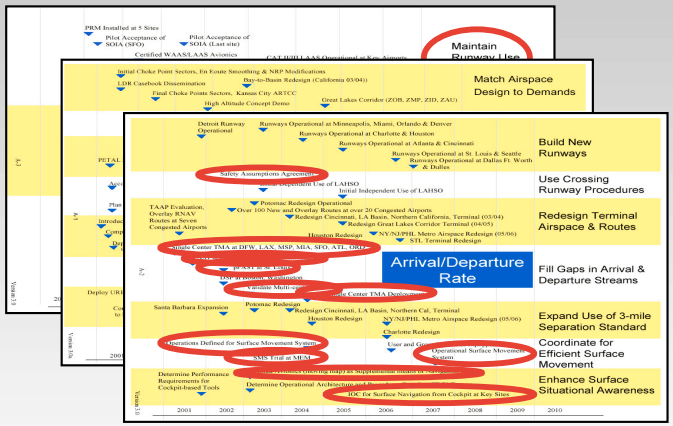
Ongoing NASA/FAA Collaboration

NASA is currently supporting FAA Operational Evolutionary Plan (OEP):

Programs

- NASA participated in planning
- NASA is in partnership on critical path

Organization of challenges addressed by OEP



NASA's technology is prominent in the FAA's roadmaps

The NASA Role

NASA provides enabling technologies, expertise, state-of-the-art facilities, and technology solutions:

Economic Growth
- Productivity
- Global Competition
- Fullest Commercial Use

National Security
- Air Superiority
- Global Mobility

Quality of Life
- Freedom of Movement
- General Welfare

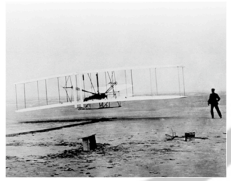
First Century of Aviation Progress

Technology advances have enabled today's world of aviation . . .

Aviation Progress Benefits Society

Glass Cockpit

KC-135/707, Jet Age



Wright Flyer

DC-3, Riveted Metal Structure, Retractable Gear

Air Traffic Radar

777, Supercritical Wing, Highly Reliable Engines

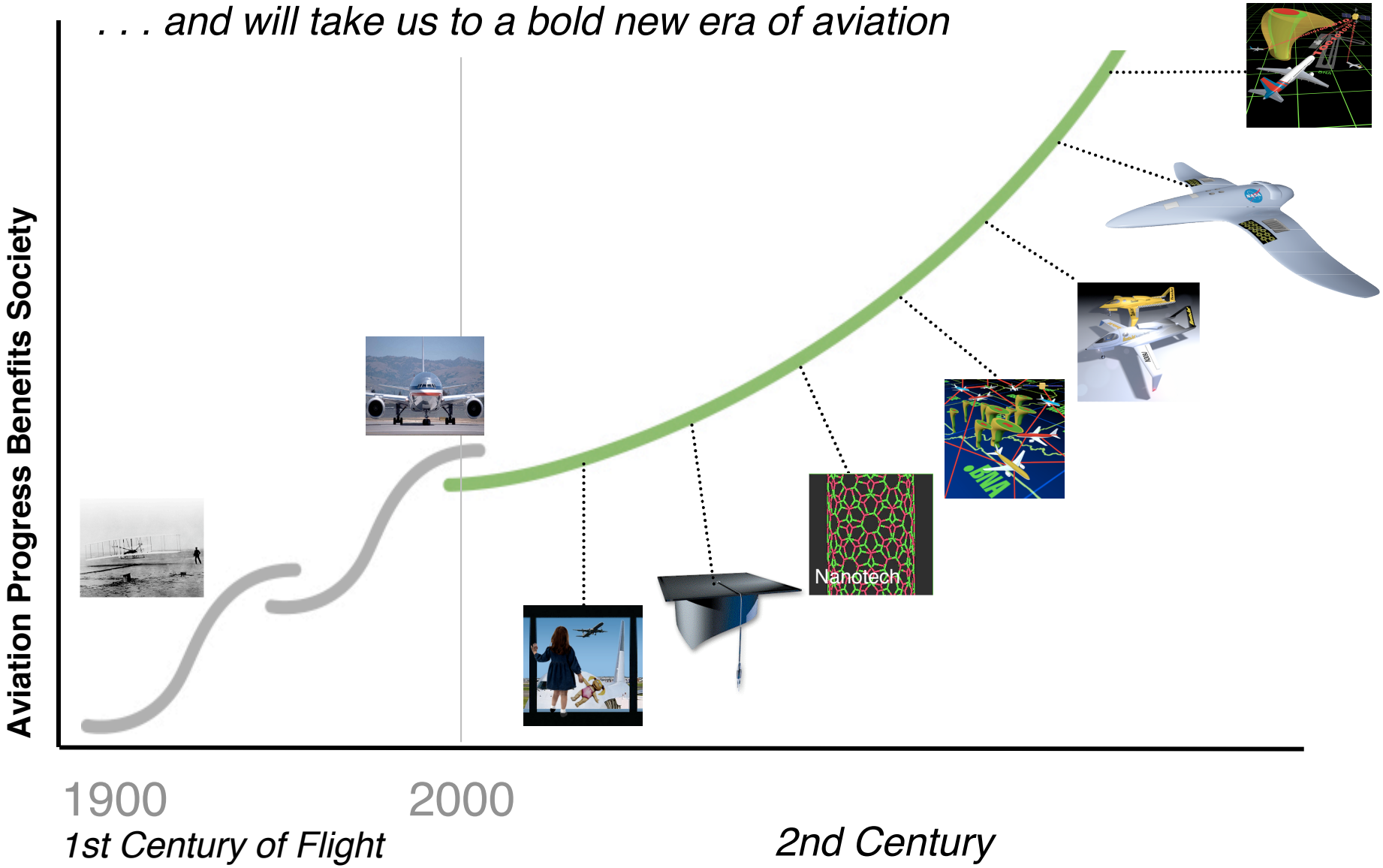
B-47, Swept Wing, Jet Propulsion

Constellation, Pressurized Cabin, Limit on Piston Propulsion

1900 1950 2000

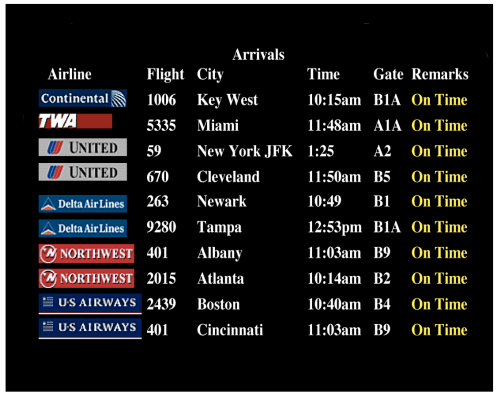
Aviation's Future is Driven by Technology

. . . and will take us to a bold new era of aviation



A Bold New Era is Possible

A Bold New Era of Aviation is Possible



Arrivals

Airline	Flight	City	Time	Gate	Remarks
Continental	1006	Key West	10:15am	B1A	On Time
TWA	5335	Miami	11:48am	A1A	On Time
UNITED	59	New York JFK	1:25	A2	On Time
UNITED	670	Cleveland	11:50am	B5	On Time
Delta Air Lines	263	Newark	10:49	B1	On Time
Delta Air Lines	9280	Tampa	12:53pm	B1A	On Time
NORTHWEST	401	Albany	11:03am	B9	On Time
NORTHWEST	2015	Atlanta	10:14am	B2	On Time
US AIRWAYS	2439	Boston	10:40am	B4	On Time
US AIRWAYS	401	Cincinnati	11:03am	B9	On Time

■ On-Time–All the Time

■ Freedom of Mobility, Access to Communities Large and Small

The New Times

National Edition

VOL CLI.....No. 51,951 WEDNESDAY, NOVEMBER 28, 2001 ONE DOLLAR

ADVANCED TECHNOLOGY ELIMINATES AIRPORT EMISSIONS

Advances in evolving technologies have the potential to change aviation in a way that will dwarf achievements of the past. Imagine having on-demand as well as scheduled air mobility, not just to hundreds, but to thousands of communities throughout the nation and the world; traveling where we want, when we want, faster, safer, and with far fewer delays; having access to rural areas no matter how remote; and having direct access to urban centers no matter how congested.

Imagine the ability to provide same-day delivery of personal packages from any place of business to any address.

Imagine projecting our military might from bases in the United States to hot spots anywhere on the globe the same day as conflicts arise; and deploying surveillance devices to

Six Communities Vie for New Neighborhood Airport

Today's aviation system is a system of systems. It is complex and highly integrated, involving some of the most advanced technologies produced by our contemporary society. The interrelationship of the many systems that make up

Today's aviation system is a system of systems. It is complex and highly integrated, involving some of the most advanced technologies produced by our contemporary society. The interrelationship of the many systems that make up

ADVANCED TECHNOLOGY REDUCES NOISE TO WITHIN THE BOUNDRIES OF THE AIRPORT

Today's aviation system is a system of systems. It is complex and highly integrated, involving some of the most advanced technologies produced by our contemporary society. The interrelationship of the many systems that make up aviation for technology evolved throughout the 20th century.

This system incremental evolution has produced an economical, effective mode of transportation systems for passengers and cargo with a safety record unmatched among all other modes of transportation. Initially, human investment and ingenuity were the only bounds to growth in aviation. More recently, system expansion has encountered real and difficult for the next physical constraints. The capacity of the Air Traffic

■ Clean, Quiet, Good-Neighbor Airports

■ Aviation Security and Safety

■ Meeting the Changing Threat

■ New Choices in Personal Air Transportation

Organization of the Aeronautics Blueprint

The Blueprint has four major elements:

Economic Growth
- Productivity
- Global Competition
- Fullest Commercial Use

National Security
- Air Superiority
- Global Mobility

Quality of Life
- Freedom of Movement
- General Welfare

DoD | Aero Industry | DOT

1. The Airspace System
2. Revolutionary Vehicles
3. Security and Safety
4. An Educated Workforce

Aeronautics Blueprint — A Strategy Based on System Analysis

Toward A Bold New Era of Aviation: 2002 2005 2008 2009 2012 2018 2025

Collaborative Partners

Investment Strategy

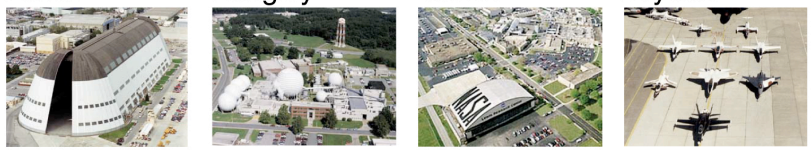
Research and Systems Engineering

Government, Industry, and Academia collaborations

- Systems engineering
- Defining requirements
- Research & technology development

NASA Research Centers:

Ames | Langley | Glenn | Dryden



- Information Technology
- Flight Path Monitoring
- Simultanious Operations
- High-resolution Weather
- Nanotechnology
- Morphing Airframe
- General Aviation
- Precision Navigation
- Advanced Sensors
- Propulsion
- High-Flow Airports
- Streaming Flight Recorder
- Refuse-to-Crash
- Synthetic Vision
- Aging Aircraft

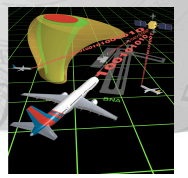
National Goals

Economic Growth
- Productivity
- Global Competition
- Fullest Commercial Use

National Security
- Air Superiority
- Global Mobility

Quality of Life
- Freedom of Mobility
- General Welfare

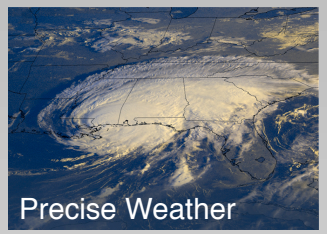
The Airspace System



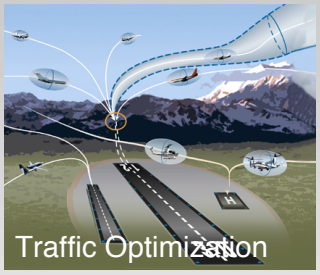
Today's Challenges:

- **Overcome reduced throughput in bad weather**
- **Eliminate en route congestion and the "domino effect" throughout the system**
- **Keep pace with demand for arrival and departures at benchmark airports***
- **Increase situational awareness in the system**

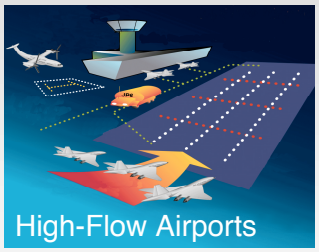
Technology Solutions:



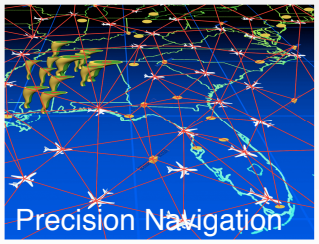
- **High-resolution weather**
  - Precise forecasts
  - Precise wake vortex knowledge



- **System-level traffic flows optimization**
  - Separation assurance for complex traffic flows



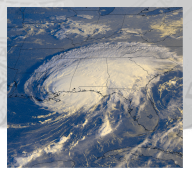
- **High-flow airports**
  - No gaps in arrival and departure streams
  - Efficient surface movement and rapid reconfiguration



- **Communication, navigation, and surveillance**
  - High-bandwidth and reliable data transmission
  - Precision navigation
  - System wide coverage

* Statistic: 64 major airports handle 85 percent of air traffic in the U.S.

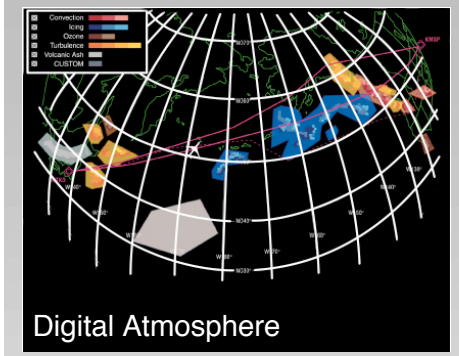
The Airspace System–Weather



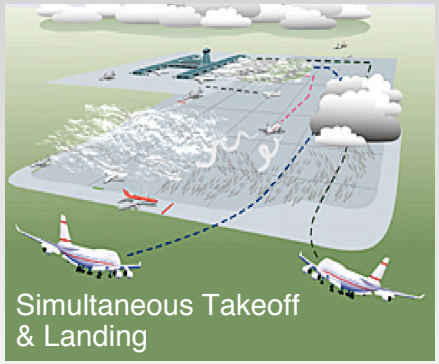
Today's Challenges:

- **Reduce disruptions of en route traffic due to bad weather**
- **Eliminate delays in terminal area airspace**
  - Efficiently manage terminal area traffic flow
  - Understand wake vortex movement and dissipation

Technology Solutions:

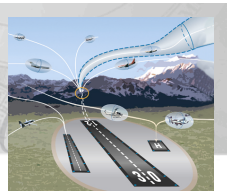


- **Complete digital knowledge of the en route atmosphere**
  - Precision forecasts
  - Sensors
  - Worldwide measurements
  - Data processing
  - Information dissemination



- **Precise local weather forecasts integrated with airport operations**
  - Reliable prediction and conformation of wake vortices integrated with atmospheric conditions

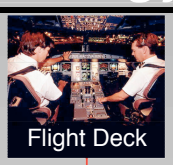
The Airspace System–Traffic Optimization



Today's Challenges:

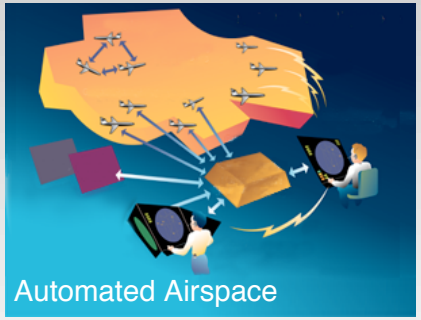
- **Eliminate the air traffic "domino effect" across the National Airspace System**
  - Geographic "choke points"
  - Limited airspace/sector flexibility
- **Increase airline flexibility to manage contingencies**
- **Minimize congestion in complex traffic situations**

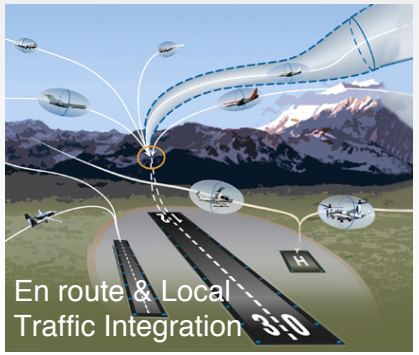
Technology Solutions:




Airline Operations

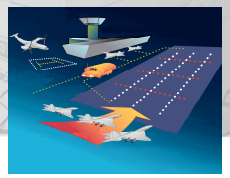

Controllers





- **National airspace management**
  - Remove restrictions across facilities and sectors
  - Distributed air-ground traffic management
  - Assured safe and efficient flight path
  - Use of precision weather and aircraft position
- **Interactive monitoring and goal setting**
- **System-level (en route and local) traffic flow planning and decision making**

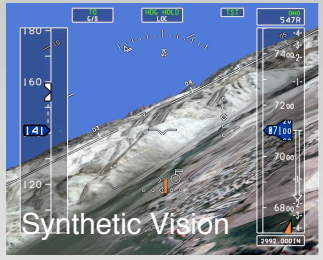
The Airspace System–High-Flow Airports

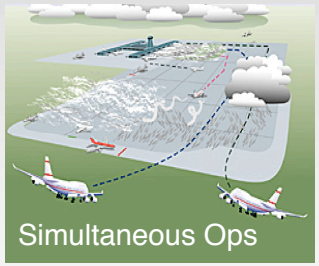


Today's Challenges:

- **Eliminate gaps in arrival/departure streams.**
- **Increase airport operations in bad weather.**
  - Single-runway use limits
  - Parallel-runway use limits
- **Enable rapid reconfiguration of runways.**
- **Integrate short-haul aircraft into airport operations.**
- **Exploit 5,000 underutilized public airports.**

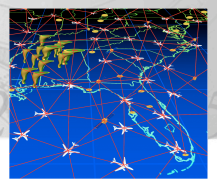
Technology Solutions:





- **Integrated arrival, departure, and surface decision-support tools**
  - Precision spacing and merging
  - Optimized surface operations
- **All-weather situational awareness and response**
  - Synthetic vision
  - Computer-assisted air and ground coordination
- **New airport design and operation models**
  - Intelligent runways and taxiways
  - Simultaneous landings and departures
- **Smart non-towered airports**
  - Autonomous sequencing and scheduling

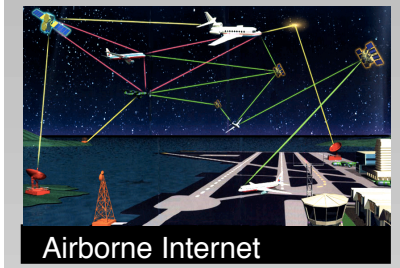
The Airspace System–CNS*



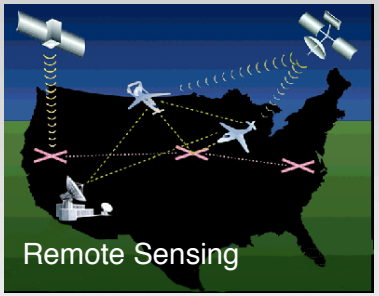
Today's Challenges:

- **Congested frequency spectrum limiting air traffic growth**
- **Voice-based air traffic control cannot support complex air traffic management concepts**
- **System provides insufficient security & integrity**
- **Communications capacity cannot support future air traffic management**
- **Coverage is lacking in remote and oceanic regions**

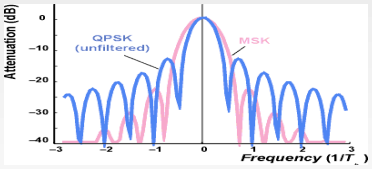
Technology Solutions:



- **Airborne internet**
- **Secure networked communications**
- **Remote surveillance of all airspace**



- **Satellite communications and surveillance**
  - Global surveillance and communications
  - Real-time cockpit weather and other hazard awareness



Secure digital communications

- **Digital broadband communication**

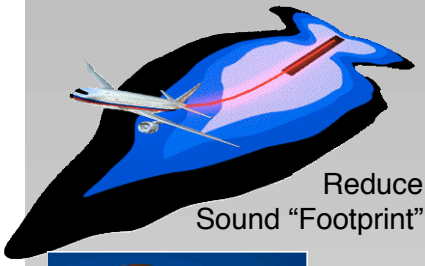
*Communication, Navigation, and Surveillance

Revolutionary Vehicles

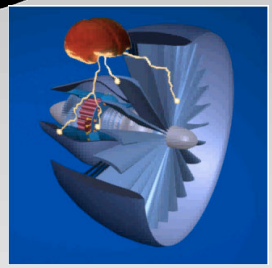
Today's Challenges:

- **Reduce noise**
  - Eliminate airport restrictions
- **Lower emissions**
  - Reduce greenhouse gases
  - Improve local air quality
- **Improve safety**
  - Reduce the accident rate
- **Enhance capabilities–advance technology**
  - Autonomous operation
  - Supersonic overland flight
  - Runway independence

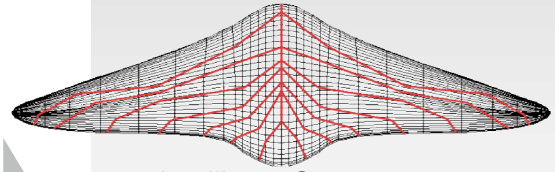
Technology Solutions:



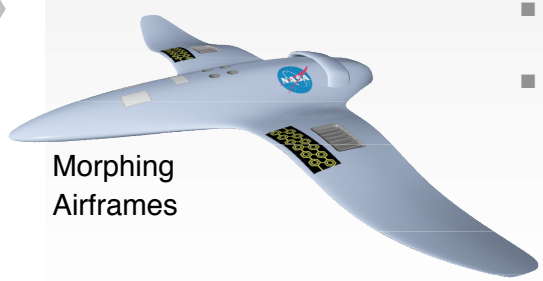
Reduce Sound "Footprint"



Intelligent Propulsion System



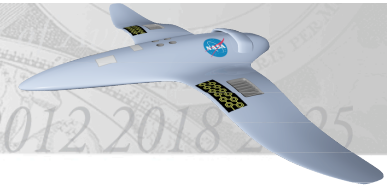
Intelligent Sensors



Morphing Airframes

- **Integrated airframe and propulsion systems**
- **Active flow and noise control**
- **Intelligent propulsion systems**
- **Fuel-efficient vehicles**
- **Robust flight control**
  - Reconfigurable control laws
- **Integrated vehicle health monitoring**
- **Automated decision aids**
- **Advanced vehicle concepts**

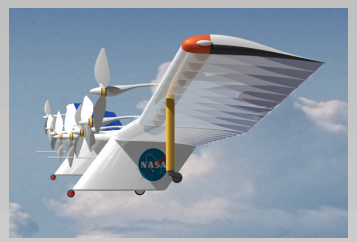
Revolutionary Vehicles–Capabilities



Today's Challenges:

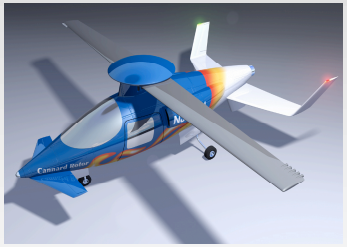
- **Long-duration and large, long-haul transportation**
- **High-speed commercial transportation**
- **Quiet and efficient runway-independent aircraft**
- **Autonomous operations capability**

Future Possibilities:

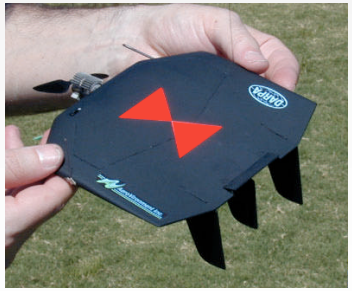


- Months aloft at high-altitudes and long distances

- Quiet, efficient, affordable supersonic flight

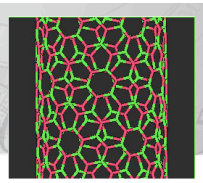


- Extremely short takeoff and landing–doorstep-to-doorstep



- Intelligent flight controls, micro-vehicles to transports

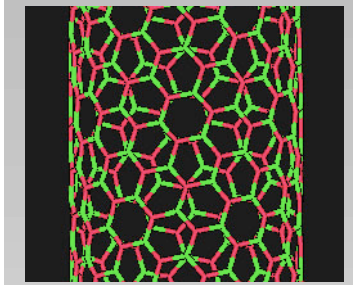
Revolutionary Vehicles–Technologies



Today's Challenges:

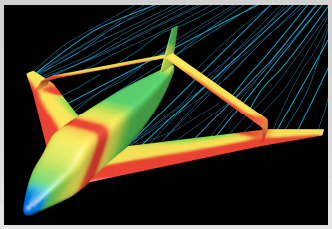
- **Develop light, strong, and structurally efficient air vehicles.**
- **Improved aerodynamic efficiency.**
- **Design fuel-efficient, low-emission propulsion systems.**
- **Develop safe, fault-tolerant vehicle systems.**

Technology Solutions:



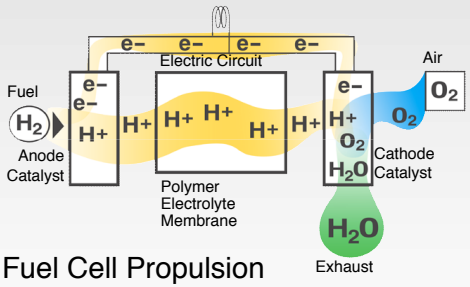
Nanotube

- **Nanostructures: 100 times stronger than steel at 1/6 the weight**
- **Active flow control**



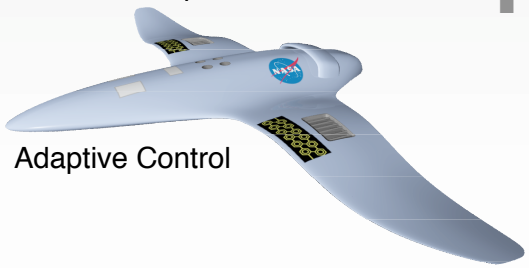
Active Flow Control

- **Distributed propulsion**
- **Electric propulsion, advanced fuel cells, high-efficiency electric motors**



Fuel Cell Propulsion

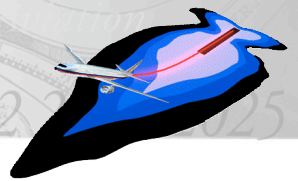
- **Integrated advanced control systems and information technology**



Adaptive Control

- **Central "nervous system" and adaptive vehicle control**

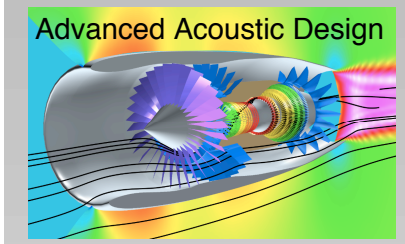
Revolutionary Vehicles–Noise



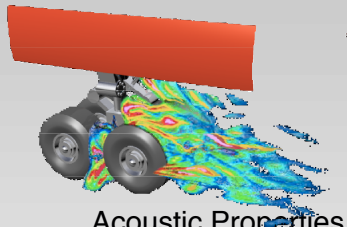
Today's Challenges:

- **Keep noise inside airport boundaries.**
  - Reduce the number of restrictions from the current 825 worldwide.
  - Eliminate the need to sound-condition homes near airports.
  - Revolutionize how citizens view airports.

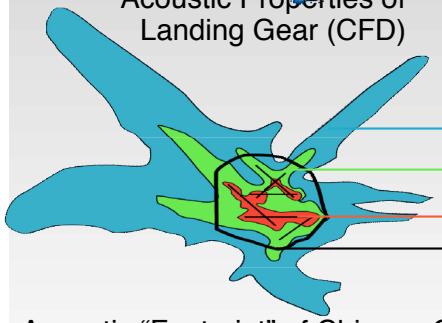
Technology Solutions:



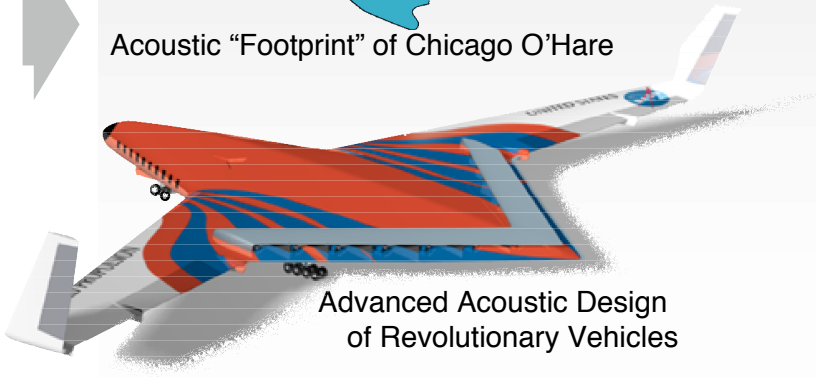
- **Eliminate noise by improving the design of engines, landing gear, and airframes.**
  - Understand the sources of noise.
  - Integrate emerging materials, structures,and flow-control technologies.
  - Develop revolutionary vehicle designs.



Acoustic Properties of Landing Gear (CFD)



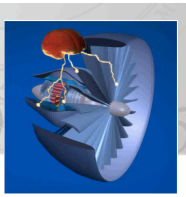
Acoustic "Footprint" of Chicago O'Hare



Advanced Acoustic Design of Revolutionary Vehicles

* DNL 55 is the EPA outdoor noise exposure level "requisite to protect the public health and welfare with an adequate margin of safety."

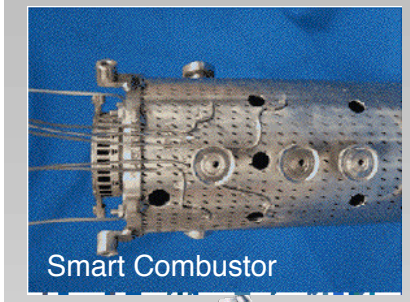
Revolutionary Vehicles–Emissions

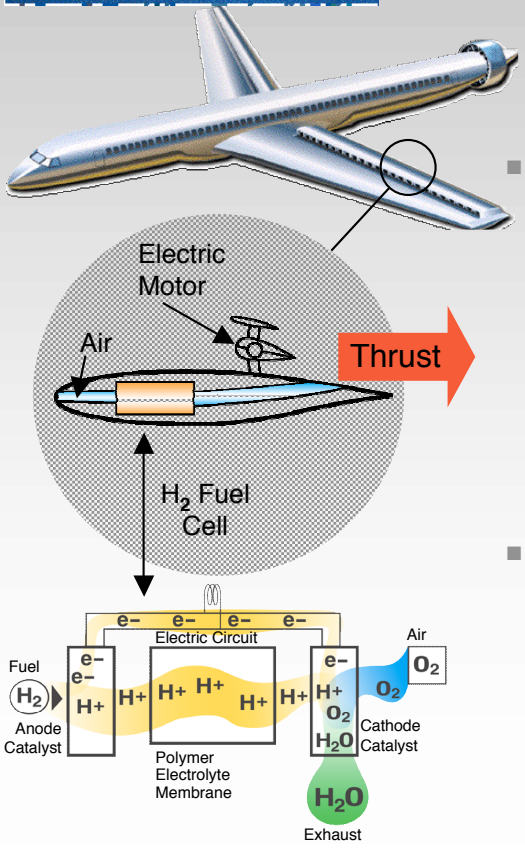


Today's Challenges:

- **Improve local air quality; reduce NO_x**
  - Projected to increase fourfold by 2050
- **Reduce impact of aviation on global air quality; reduce CO_2**
  - Projected to increase threefold by 2050

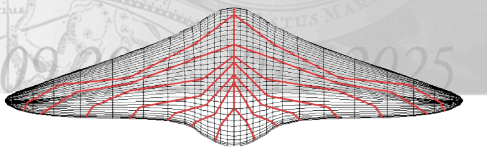
Technology Solutions:





- **Intelligent combustors**
  - Sensors and actuators to control the combustion process
  - Smart materials
- **Increased fuel efficiency**
  - Ultra-lightweight and efficient aircraft
  - Dual-fan engines
  - Distributed propulsion
- **Electric propulsion**
  - Fuel cells
  - Global hydrogen generation and distribution

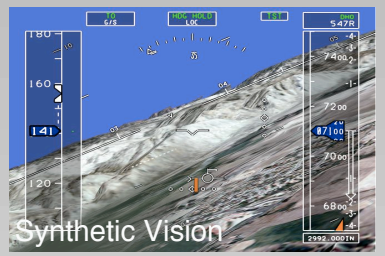
Revolutionary Vehicles–Safety



Today's Challenges:

- **Provide all-weather visibility.**
- **Eliminate human error.**
- **Reduce component failures.**
- **Minimize the impact of weather hazards.**
- **Identify hidden risks.**

Technology Solutions:


Synthetic Vision

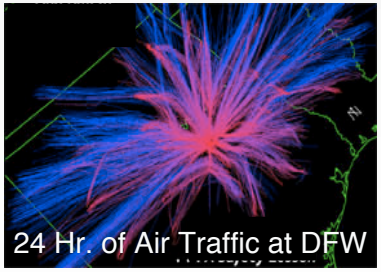
- **Synthetic vision provides visibility in all conditions**
- **"Refuse to crash" flight controls with digital terrain technology**


Human Centered Design

- **Human-centered designs**
- **Fault detection and reconfigurable systems**

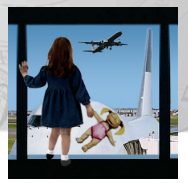

Precision Digital Airspace

- **Self-healing systems**
- **Precise knowledge of atmospheric conditions**


24 Hr. of Air Traffic at DFW

- **Advanced modeling of air traffic to identify and minimize risk**

Aviation Security and Safety



Today's Challenges:

- **Protect the public, passengers, and crew from danger or injury.**
- **Protect the airplane from threats.**
- **Prevent the aviation system from being used for malicious purposes.**
- **Develop solutions maximizing security of the Nation's aviation system while minimizing cost and unintentional consequences.**

Technology Solutions:

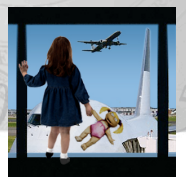

Aircraft System Protection


Safe Flight Intervention


Protect the Public

- **Aircraft and systems hardening**
- **Flight operations with enhanced procedures and monitoring**
- **Air traffic surveillance and intervention**
  - Onboard flight control
  - Ground control override
- **Enhance security systems through application of information technology**
  - Passenger threat assessment from reservation to boarding
  - Analysis of security data from 100's of airports and thousands of flights

Aviation Security and Safety–Aircraft Hardening



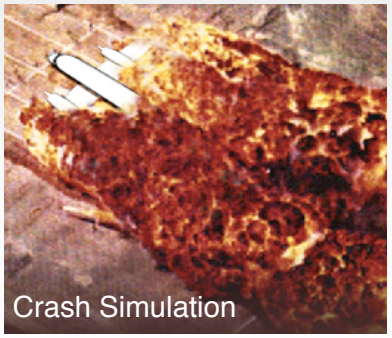
Today's Challenges:

- **Design systems to tolerate failures and damage.**
- **Provide onboard network security and protection.**
- **Minimize fuel-fed fires**

Technology Solutions:

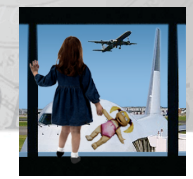

Blast-Resistant Luggage Container, FAA Research


Integrated Security Systems


Crash Simulation

- **Blast-resistance structures, which can withstand damage and land safely**
- **Fault detection and reconfigurable avionics**
- **Self-healing systems**
- **Recoverable computers with Software-virus protection**
- **Network intrusion prevention**
- **Secure communications**
- **Self-extinguishing fuel**

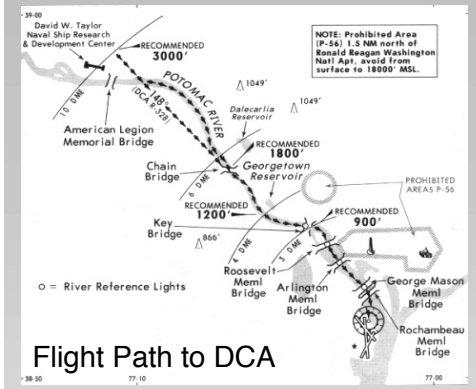
Aviation Security and Safety–Flight Procedures and Monitoring



Today's Challenges:

- **Assure predictable approaches to metropolitan areas and around prohibited locations.**
- **Increase situation awareness of terrain and special airspace.**
- **Improve detection of deviations from the intended flight path.**

Technology Solutions:



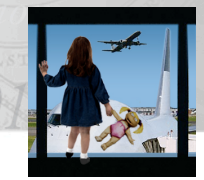
Flight Path to DCA


Approach To DCA


Flight Path Monitoring

- **Precise flight path management**
  - Complex curved approaches
  - Four-dimensional approaches
- **Advanced modeling and evaluation of air traffic to identify and minimize risk**
  - "Intelligent" advisor for authorities
  - Simulate scenarios for training and mitigation strategy development
- **Remote monitoring of flight path conformance**
  - Notification of deviations
  - Rapid intervention strategy

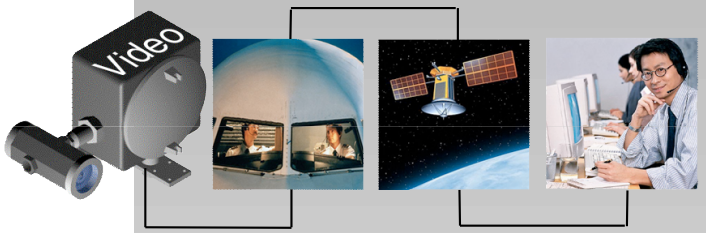
Aviation Security and Safety–Surveillance and Intervention



Today's Challenges:

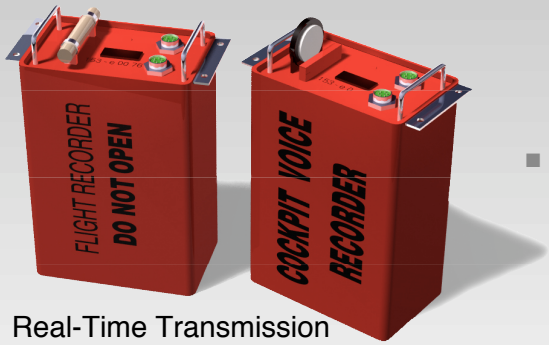
- **Rapid detection of any state of duress on an airborne aircraft**
  - Terrorist on board
  - Hazardous materials or other on-board threats
- **Prevent intentional, destructive pilot-controlled flight.**
- **Prevent hazardous flight from non-malicious pilot actions.**

Technology Solutions:



Flight Path Monitoring

- **Remote audio and visual links to cabin and cockpit**
  - Real-time cockpit and flight data transmission to a remote monitoring center

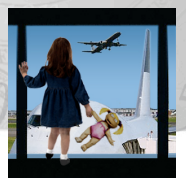


Real-Time Transmission
Cockpit Flight Recorder

- **"Refuse to Crash" flight system can correct pilot error and prevent sabotage**
  - Real-time dynamic avoidance threshold algorithms
  - Automatic avoidance maneuvers, autonomous navigation, and landing
  - Ground control override

Ground Control Override

Aviation Security and Safety–Information Technology



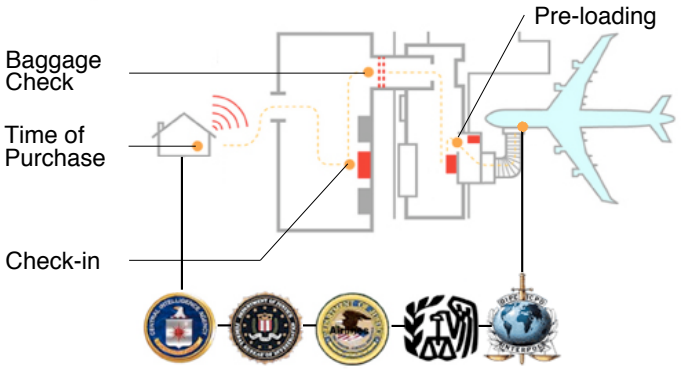
Today's Challenges:

- **Rapid pre-departure passenger screening and threat assessment**
- **Identify trends in system security status**

Technology Solutions:

Threat Assessment

- **Real-time passenger threat assessment from reservation to boarding**
  - Intelligent searches of distributed databases
  - Biometric identification
  - Context-sensitive threat evaluation
- **Aviation Security Reporting System**
  - Anonymous submission of security incidents
  - Data Mining to identify trends of concern and initiate preventative action



National Information System for Transportation Security

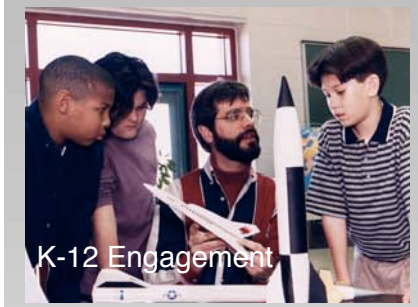
State-of-the-Art Educated Workforce

Educated Workforce–Approach to Education

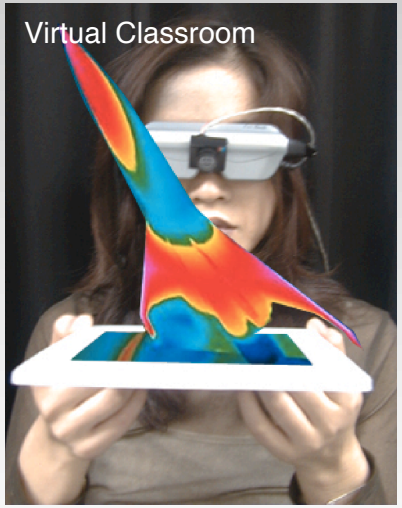
Today's Challenges:

- **Raise the interest in science and engineering in elementary, middle, and high schools.**
- **Prepare future graduates for a world of rapid technological change, complex systems, and advancements around the world.**
- **Maintain the high-tech workforce on par with the continuously advancing state of technology.**

Technology Solutions:


K-12 Engagement

- **Foster interest and excitement in aerospace–establish an exciting vision for aeronautics**


Virtual Classroom

- **Stimulate curriculum change and virtual and collaborative learning environments that will enhance educational relevance and scope**


Distributed Learning

- **Create life-long learning system that links classrooms to laboratories and on-the-job experiences**

Educated Workforce–Accomplishing the Enterprise Mission

Today's Challenges:

- **Adjust to the rapid loss of senior scientists and engineers (baby boomer demographics and reduced interest)**
- **Ensure seamless access to specialized talents and geographically dispersed teams.**
- **Keep pace with the rapid change of technology.**
- **Fill-in the knowledge gaps of aerospace research and technology to support major advances for the next generation of aerospace products.**

Technology Solutions:

- **Develop long-term partnerships between government, universities, and industry research entities**
- **Create virtual collaborative research laboratories working on multi-discipline projects**

- **Workplace virtual classrooms support life-long and advanced distributed learning**
- **Adaptive learning computer systems for access to global scientific and technology knowledge**

Summary and Actions

Summary

- Driven by technology advances, aviation has progressed remarkably over the past century.
- Today's air transport system is facing severe constraints on further growth and service to the Nation.
- New technologies and operational concepts, nearly in hand and in early development, offer the potential to far surpass those constraints and create a new level of performance and capability in aviation.
- NASA, academia, FAA, DOT, DoD, and industry are needed in order to realize this vision.
- Now is the time to aggressively pursue
  - advanced concepts for the airspace system;
  - revolutionary vehicles with significantly greater performance;
  - new paradigms for safety and security; and
  - the development of a capable, flexible workforce of the future.

- **The cost of inaction is gridlock, constrained mobility, unrealized economic growth, and loss of U.S. aviation leadership.**

NASA's First Steps to Achieve the Vision

- Structure investments and performance metrics based on systems analysis and public good.
- Evaluate, realign, and strengthen our workforce, facilities, partnerships, and ways of doing business.
- Renew our focus on innovation in engineering tools and capabilities for complex aerospace systems:
  - Act in partnership with industry
  - Act as a catalyst for the future workforce
- Restructure approach and portfolio for long-term research:
  - New national technology competencies
  - New, expanded approach to University Research Center partnerships
- Continue to strengthen interagency partnerships to meet national needs.

NASA is embarking on technological changes for the 21st century.